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Selective feeding on a maple leaf by *Oniscus asellus* (Isopoda)

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With one figure

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1. Introduction

It has been reported that isopods and other invertebrates are able to distinguish between food sources e.g. different species of leaves or leaves in various states of decay (BECK & BRESTOWSKY 1980, RUSHTON & HASSALL 1983). However, the feeding pattern of isopods on a particular leaf is not well documented.

A culture of *Oniscus asellus* L. was continuously given air dried maple leaves (*Acer platanoides* L.) as food. The newly fallen leaves which were sampled in late September were covered in places by black colonies of the fungal tar spot disease (*Rhytisma acerinum* FR.). The fungus infects maple leaves on the tree by overwintering ascospores (WEBSTER 1980). About 2 months after the infection, cells of the mesophyll, and especially those of the upper epidermis, are filled with mycelium. Apothecia develop and the hymenium is roofed over by several layers of dark cells formed within the upper epidermis. The asci complete their development on the fallen leaves.

It was noted that the isopods always began to consume the fungal colonies with underlying leaf tissue and thereafter the leaf areas around. This paper follows the fragmentation of maple leaves and illustrates, by use of time lapse photographs, that *O. asellus* can distinguish between different parts of a leaf and discusses 3 possible reasons why the isopods make this kind of choice.

2. Materials and methods

Two air dried maple leaves with about 10% of the surface covered with colonies of the fungus *Rh. acerinum* were put on moistened filter papers in 2 plastic boxes (210×210×65 mm). Ten adult *O. asellus* were added to each box. The isopods were reared in darkness at 20 °C. On the day when the experiment started and every week during 5 consecutive weeks, fecal pellets were brushed off and the leaves or their remains were photographed.

Three different leaf parts were selected for determination of total carbon and nitrogen.

1. Parts free from veins but covered by *Rh. acerinum*, referred to as "*Rh. acerinum* parts".
2. Leaf parts without veins or visible colonies of microorganisms, referred to as "plain surface".
3. Veins.

Carbon was measured in triplicate samples (of about 40 mg) on a LECO carbon analyser model CR 12. Nitrogen was measured in triplicate samples (of about 20 mg) on an ANTEK nitrogen analyser equipped with a model 773 pyroreactor, a model 720 nitrogen detector and a model 731 microprocessor.

Triplicates (of about 40 mg) of newly collected samples of *Rh. acerinum* parts and of the plain surface, respectively, were homogenized with sterile tap water in a teflone homogenizer. After serial dilution, 0.1 ml of the solution from each dilution tube was spread on 1.5% agar plates containing either, 1.5% malt extract, and supplied with 30 ppm chlortetracycline to prevent bacterial growth, or 0.3% tryptone-soya extract, and supplied with 30 ppm cycloheximide to prevent fungal growth. The numbers of colony-forming units were counted after 4 days at 10× magnification. To get the number of microorganisms on a xeromass basis, separate samples were weighed and then reweighed after drying for one week in a desiccator.

Data were compared by analysis of variance and Student's t-test.

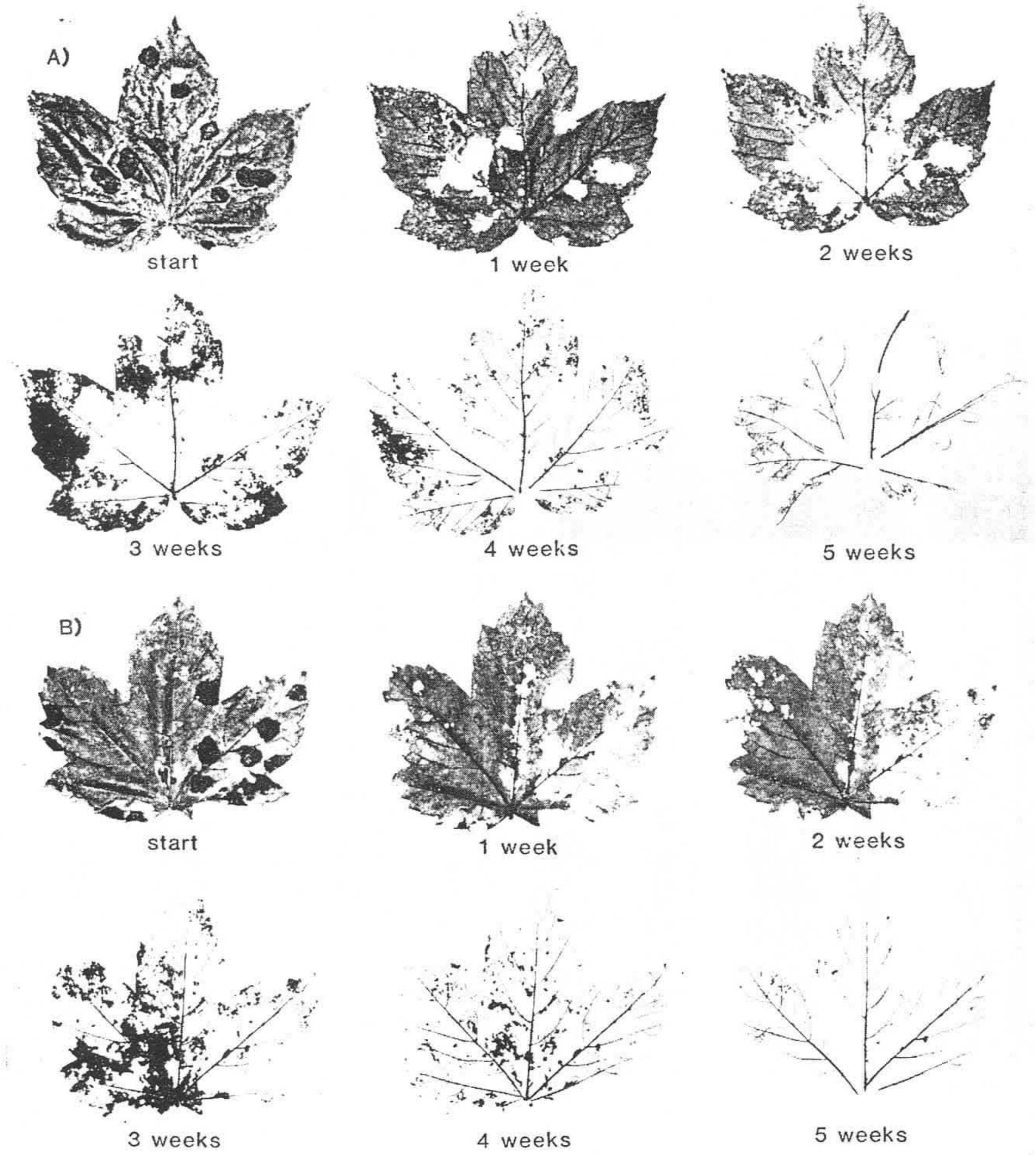

Fig. 1. Time-lapse photographs of 2 maple leaves presented to *Oniscus asellus*. Time interval between each photo in a series was one week.

3. Results

All *Rh. acerinum* parts were entirely consumed during the first week (Fig. 1), while the remaining leaf material was uneaten. The second week the isopods continued to feed mostly on the areas surrounding former fungal colonies. During the third week most of the remaining leaf material was grazed. The isopods did not, however, consume all the material but scraped off and softened the surface. At week 4 most of the plain surface except for many veins had been consumed. When the experiment was terminated the isopods had started to consume veins, mostly the thin ones.

Both the carbon and the nitrogen contents were highest in *Rh. acerinum* parts and lowest in veins (Table 1). The C/N ratio was 1.3 times higher in plain surface and 3.1 times higher in veins than in *Rh. acerinum* parts.

Table 1. Concentration (mg g^{-1} m_x) of carbon and nitrogen in different leaf parts of *Acer platanoides* L.

	concentration (mg $g^{-1}m_x$)		
	C	N	C/N ratio
Rh. acerinum parts	486.6 ± 4.5	24.2 ± 1.5	20.1
plain surface	429.0 ± 10.0	15.9 ± 0.6	27.0
veins	412.0 ± 5.8	6.6 ± 0.3	62.4
	$F = 87.98$	$F = 249.37$	
	$df = 2,6$	$df = 2,6$	
	$p < 0.001$	$p < 0.001$	

Note: Analysis of variance applied (mean $\pm$ S.D.; $n = 3$).

Table 2. Numbers of colony-forming units of microorganisms from different leaf parts of *A. platanoides* developing on agar plates

	no $\times 10^{-6}$ g^{-1} m_x	
	fungi	bacteria
Rh. acerinum parts	68.3 ± 13.2	94.3 ± 13.5
plain surface	191.7 ± 25.3	273.8 ± 48.8

Note: Means ($n = 3$) from various leaf parts are significantly different ($p < 0.001$) both for fungi and bacteria (Student's t-test).

The numbers of colony forming units of both fungi and bacteria were about 3 times higher on the plain surface than on *Rh. acerinum* parts (Table 2).

4. Discussion

The photographs show that *O. asellus* really choose the leaf parts in the order: 1. *Rh. acerinum* parts. 2. plain surface. 3. veins. There are at least 3 explanations why some leaf parts are chemically modified and favoured by the isopods;

A. The area or the microorganisms growing on it contain or produce compounds of high nutrient quality or attractiveness to the isopods.

B. Microorganisms exude compounds that prevent growth of other, unpalatable, microorganisms.

C. Microorganisms degrade unpalatable compounds in the leaf tissue.

The highest nitrogen content was found in the most preferred parts (*Rh. acerinum* parts) and the lowest one was in the least preferred parts (veins). A great portion of the total nitrogen in fungal colonies is probably bound to high quality nutrients as amino acids and proteins (Kaushik & Hynes 1968, Bengtsson 1983), which at least partly can be assimilated by the isopods. The fungus *Rh. acerinum* may also contain or produce vitamins or other compounds essential to isopods. Fungal species have been found to increase the palatability of leaves and detritus to invertebrate consumers, both terrestrial (Cooke & Luxton 1980) and aquatic ones (Kostalos & Seymour 1976, Suberkropp *et al.* 1983, Rossi 1985).

The preferred *Rh. acerinum* parts had the lowest number of other fungi and bacteria developing on agar plates. Microorganisms may be distasteful or toxic to isopods as some fungal species are to springtails (Visser & Whittaker 1977), or may increase the palatability of detritus as fungal species, but not bacteria, do for amphipods (Kostalos & Seymour 1976). Bacteria have a cellwall that requires special enzymes to digest (Hayashi *et al.* 1973). If the isopods lack necessary enzymes they cannot utilize nutrients incorporated in the bacteria, and food containing a high amount of bacteria could be of low value for them. Bacteria are often numerous in guts and fecal pellets of isopods (Brown *et al.* 1978), increase

in numbers there even though lysis occurs (REYES & TIEDJE 1976), and may assimilate nutrients which otherwise could be available to the isopods. Thus the low number of bacteria and other fungi could be a reason for the selection of *Rh. acerinum* parts.

When *Rh. acerinum* infects the green leaves, the tree may react by producing growth inhibiting substances and concentrate them around the place of fungal attack since the colonies never grow larger than about 12—15 mm. Trees normally use tannins and phenolics as defence substances. Tannins form relatively indigestible complexes with proteins of the leaves and may also complex with the digestive enzyme itself. This reduces the availability of nitrogen for pathogens and consumers (FEENY 1976, RHOADES & CATES 1976). Some microorganisms are, however, able to degrade phenolic and tannic compounds (PUGH 1974), which may increase the palatability of the leaf to consumers. Phenolics can also be digested by isopods. NEUHAUSER & HARTENSTEIN (1978) have shown an assimilation of about 50% of the phenolic content of leaves by *O. asellus* and 2 other species. Thus isopods could well start to feed on the *Rh. acerinum* parts and then continue feeding on the surrounding areas which may have a high content of defence substances, but also of nutrients leached from the fungus.

Whatever the reasons are for the isopods to select leaf parts in a certain order, the occurrence of microorganisms seems to guide the choice. They either change the substrate in a positive/negative way or, the microorganisms themselves are food of high or low quality. Microorganisms normally grow patchily and in small colonies in the terrestrial environment. Thus, a litter layer cannot be regarded as food of homogeneous quality for the isopods but instead as a 3-dimensional mosaic of food patches, varying in attractiveness and quality.

5. Zusammenfassung

[Selektiver Fraß der Isopode Oniscus asellus an Ahornblättern]

Bei der Züchtung von *Oniscus asellus* auf Ahornblättern (*Acer platanoides* L.) wurde beobachtet, daß die Isopoden an verschiedenen Teilen des Plattes wie folgt fraßen: (1) Teile mit Kolonien von der Pilzart *Rhytisma acerinum* FR. (2) Teile ohne sichtbare Pilzkolonien („saubere Flächen" genannt). (3) Blattnerven. Das C/N Verhältnis war am niedrigsten in den Teilen mit den Kolonien und am höchsten in den Nerven. Die Anzahl der Pilze und Bakterien, die sich auf Agar-Schalen entwickelten, betrugen ungefähr $^1/_3$ in den Proben von den Kolonieteilen verglichen mit diesen von den sauberen Flächen. Drei Erklärungen, warum die Isopoden gerade diese Wahl treffen, wurden diskutiert: (A) Die bevorzugte Fläche oder der Mikroorganismenbewuchs darauf enthalten Stoffe von hoher Nahrungsqualität oder sind attraktiv für die Isopoden. (B) Mikroorganismen sondern Stoffe ab, die das Wachsen von anderen ungenießbaren Mikroorganismen verhindern. (C) Mikroorganismen bauen ungenießbare Stoffe im Blattgewebe ab.

Schlüsselwörter: Isopoda, *Oniscus asellus*, Nahrungswahl, Mikroorganismen, Metabolismus, Ahornblätter.

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Synopsis: *Original scientific paper*

GUNNARSSON, T., 1987. Selective feeding on a maple leaf by *Oniscus asellus* (Isopoda).

When rearing *Oniscus asellus* L. on maple leaves (*Acer platanoides* L.) it was observed that the isopods fed on different parts of a leaf in the order: 1. parts with colonies of the fungal tar spot disease (*Rhytisma acerinum* FR.), 2. parts without visible fungal colonies (referred to as "plain surface"), 3. veins. The C/N ratio was lowest in the colony parts, and highest in the veins. The numbers of fungi and bacteria developing on agar plates were about $^1/_3$ in samples from the colony parts compared with those from plain surface. Three explanations why the isopods make their choice are discussed, viz: A. The preferred area or microorganisms growing on it contain compounds of high nutrient quality or attractiveness to the isopods. B. Microorganisms exude compounds that prevent growth of other, unpalatable, microorganisms. C. Microorganisms degrade unpalatable compounds in the leaf tissue.

Key words: isopod, *Oniscus asellus*, food selection, microorganisms, maple leaf, metabolism.